ECONOMIC ASSESSMENT OF CASE STUDIES BASED ON PROPOSED MINISTRY GUIDELINES FOR CLEAN-UP OF CONTAMINATED SITES

JULY 1994

Ontario

Ministry of Environment and Energy

ISBN 0-7778-3128-7

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PIBS 3198

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Economic Services Branch
and
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I. INTRODUCTION

The Ministry of Environment and Energy (MOEE) has prepared a document -- *Guideline For the Clean-up of Contaminated Sites in Ontario* (July 1994) that proposes new approaches on how sites in Ontario should be assessed for contamination and cleaned-up. This proposed guideline is intended to replace the 1989 MOEE *Guidelines for the Decommissioning and Clean-up of Sites in Ontario* and the 1993 MOEE *Interim Guidelines for the Assessment and Management of Petroleum Contaminated Sites in Ontario.*

The implications of the proposed clean-up guideline were investigated by producing representative estimates for seven specific case studies. These analyses illustrate the cost of clean-up under the current guidelines and compares it with costs in various conditions under the proposed guideline. This report focusses on the costs of site clean-up using the proposed generic approach, because this approach represents the most significant change in the proposed guideline.

The case studies completed for this report are described and conclusions based on the evaluations are drawn. Accordingly, the estimates presented here are restricted to the seven case studies and may not reflect the full range of costs and consequences that could be associated with the proposed guideline. The analyses are limited to scenarios where the property is intended for either residential or industrial land use, because these land use categories represent the most common application of the clean-up guideline.

Documents entitled *Guideline For the Clean-up of Contaminated Sites in Ontario* and *Rationale For the Development and Application of Generic Soil, Groundwater, and Sediment Criteria For Clean-up of Contaminated Sites* provide a full discussion of the proposed guideline and the process and assumptions that were made in the development of all soil, sediment and groundwater concentration criteria. These concentration criteria are referred to as generic clean-up criteria in this document.

II. BACKGROUND

Current Guidelines

Under the current guidelines, remedial action can be carried out to meet background or above background contaminant levels. Ambient or background levels are defined as the level of substance in the local area and generally require a sampling program in the local area.

The MOEE has established Upper Limit Normal (ULN) concentrations for a number of parameters in soil for instances where background levels of contaminants of concern may be elevated in the local area as a result of industrial or other activity. ULN values represent the expected maximum concentrations of substances in surface soil from areas not subject to point source emissions. It is stressed in the guidelines that ULN values are not values to trigger site clean-up but serve as indicators, which if exceeded should prompt further investigation on a case-

by-case basis.

Three options are currently offered to a proponent for developing clean-up levels above background levels:

1) **Generic Approach**: Application of relevant MOEE policies and guidelines including a set of generic clean-up criteria for 22 contaminants. Clean-up criteria are categorized by proposed land use Agricultural/Residential/Parkland vs. Commercial/Industrial and by soil texture, medium & fine vs. course for a total of four subsets of clean-up criteria. **This generic approach represents the base case for this analysis.**

2) **Criteria Developed in Other Jurisdictions**: Application of clean-up criteria developed in other jurisdictions using methods that are acceptable to the MOEE.

3) **Site Specific Clean-up Criteria**: Development and application of site specific clean-up criteria using site specific risk assessment methods.

A number of limitations have been identified in the current guidelines. These include:

- The current guidelines listed clean-up standards for only 22 inorganic contaminants when in fact, many sites in the province are also contaminated with organic compounds.

- In some instances, the grouping of the agricultural land use category with the residential and parkland use categories required criteria stringent enough to protect inappropriate ecological receptors (for example, grazing sheep). Protection of these types of receptors may have been inappropriate when designing a clean-up for residential purposes.

- The generic clean-up criteria listed apply to clean-up of both surface and sub-surface soil on a site yet receptors may not need the same level of protection from both exposure pathways.

- No consideration of soil leaching to groundwater on a site was included in the development of the generic criteria. Potable groundwater represents a potential pathway of exposure to a contaminant.

Proposed Guidelines

The proposed guideline describes a preferred practice for assessing and cleaning-up contaminated sites. It provides guidance to property owners/consultants on how to:

- assess a site for possible contamination;
- collect and analyze samples if contamination is suspected or found;
- determine if a clean-up is needed;

- clean-up the property for re-use or development.

In most cases, application of the Decommissioning Guideline is voluntary for the property owner. There is no MOEE legislative or regulatory requirement to follow the proposed clean-up guideline unless the site is causing or is likely to cause an adverse effect (as defined in the Environmental Protection Act (EPA)). In this case, a clean-up may be ordered by MOEE under existing legislation.

Under the proposed guideline, if concentration of contaminants on a property are lower than criteria values for a specific land and groundwater use, then that property is considered to be "clean" for the proposed use.

As with the current guideline, the proposed guideline allows a number of different approaches for clean-up of a contaminated site. The property owner, not MOEE, would choose one of these clean-up approaches:

- **Background Approach**
- **Generic Approach**
- **Site Specific Risk Assessment (SSRA) Approach**

Background Approach:

The background approach involves taking steps to remediate the site to rural or urban background levels for the contaminants of concern. A set of background soil criteria have been provided in the proposed guideline that have been determined from an Ontario-wide sampling program in rural and urban parks not affected by local point sources of pollution (refer to section 7.3 of the proposed guideline). Guidance is provided on how to develop background concentration criteria when no MOEE background criteria exist.

Generic Approach:

In this clean-up approach, concentration values for both soil and groundwater are proposed for 117 contaminants vs. 22 in the current guidelines.

The principles of risk assessment were used extensively to develop the generic soil and groundwater clean-up criteria in the proposed guideline. In developing generic criteria, the likely contaminant exposures of humans/environment are conservatively estimated to enable the criteria to be used for most sites. For example, while a contaminated site with clay soils would not need the same level of ground water protection as a sandy soil site, to be protective for all sites, sandy soils were assumed in developing the generic criteria.

Some sites may require the use of more stringent clean-up requirements because of their sensitivity or other conditions. These sites are referred to as sensitive sites in the proposed guideline and include sites where physical and chemical site characteristics are very different

from the conditions and assumptions considered in developing the generic criteria, or where unique, highly sensitive receptors such as an endangered species, are present at or in the vicinity of a site. In these situations, the guideline proposes that additional investigation and consultation be carried out to determine if more stringent clean-up is required (refer to section 6.0 of the guideline).

Under the Generic Approach, two clean-up options are available: Full Depth and Stratified Depth Clean-up.

A Full Depth clean-up involves remediating all contaminated soil on the property to meet the surface soil clean-up criteria.

A Stratified Depth clean-up applies surface soil criteria to a depth of 1.5m while soils below 1.5m can be remediated to sub-surface concentration levels. The Stratified Depth approach recognizes that sub-surface contaminant concentration do not, in some situations, need to be as stringent as those for surface soils.

Clean-up criteria are given in the proposed guideline for each of the following land uses and situations regarding groundwater protection:

Land-Use	Groundwater Protection
• Agricultural	• Non Potable (protects against vapour migration, contamination of surface waters)
• Residential/Parkland	• Potable (as above but added protection for drinking water use)
• Industrial/Commercial	

The selection of Full or Stratified Depth Clean-up criteria may be combined with either the Residential/Parkland or Industrial/Commercial land-use potentials and the presence of one of two groundwater protection categories to arrive at eight possible clean-up scenarios. Only one option is available for clean-up of sites under the Agricultural land use category; a full depth, potable groundwater scenario, bringing the total number of scenarios allowed under the Generic Approach to nine. The proposed guideline contains a subset of clean-up criteria for each of the nine types of clean-up.

Clean-up scenarios are defined by the intended future land use of the property (residential {RES} or industrial {IND} or agricultural {AGRI}), the intended use of the groundwater at the site (potable {P} or non potable {N}) and whether full depth {F} or stratified {S} level clean-up is chosen. Property owners can choose the future land use and the depth of clean-up, while the non Potable groundwater protection option is only available when proponents can document that present or future drinking water supplies will not be adversely affected (refer to section 2.3.3 of the proposed guideline). For example, one clean-up scenario could be a full depth clean-up for residential land use to protect potable groundwater on the site. This scenario is summarized as RES-P-F in Table 1. A summary of each of the nine potential scenarios for which clean-up criteria are available under the proposed guidelines is contained in Table 1.

Table 1
SUMMARY OF CLEAN-UP SCENARIOS

Level of Clean-up	Potable Ground Water Concern			No Potable Ground Water Concern		
	R\P Land Use	I\C Land Use	Agri Land Use	R\P Land Use	I\C Land Use	Agri Land Use
Use Surface Criteria to **Full Depth**	RES-P-F	IND-P-F	AGRI-P-F	RES-N-F	IND-N-F	N/A
Use Surface Criteria Above 1.5m and Use **Stratified** Criteria Below 1.5 m	RES-P-S	IND-P-S	N/A	RES-N-S	IND-N-S	N/A

R\P = Residential\Parkland Land Use category
I\C = Industrial\Commercial Land Use category
Agri = Agricultural Land Use category
N/A = Not Applicable

Once the property owner/consultant determines the land and groundwater use for the site, the selection of appropriate generic clean-up criteria is straightforward (refer to section 2.3 and figure 2.2 of the proposed guideline).

A comparison of the MOEE 1989 existing and the proposed soil clean-up criteria is shown in Table 2. Note that as part of the revision of the guidelines, the Agricultural land use category has been separated out from the Residential/Parkland category, that the number of contaminants for which generic criteria are available has increased and that in some instances criteria have become more stringent and in other instances, less stringent.

Table 2
COMPARISON OF ONTARIO'S PROPOSED SOIL CRITERIA WITH EXISTING GUIDELINE VALUES

Proposed Land Use Categories	Total Number of Old Criteria	Total Number of New Criteria	No. Instances where New Soil Criteria Less Stringent than Old Criteria [1]	No. Instances where New Soil Criteria More Stringent than Old Criteria
Agricultural	22	117	1 (Mercury)	3 (Lead, Antimony, Beryllium)
Residential/ Parkland	22	117	2 (Cadmium, Mercury)	3 (Lead, Antimony, Beryllium)
Industrial/ Commercial	22	117	3 (Cadmium, Lead, Mercury)	2 (Arsenic, Beryllium)

[1] Criteria are considered less stringent only if ratio of new criterion to old criterion > 1.1 and more stringent only if same ratio is < 0.9 (i.e. greater/less than 10%).
All comparisons based on final version of Tables A-D *Guideline For the Clean-up of Contaminated Sites in Ontario*; July 1994.

Site Specific Risk Assessment Approach:

Risk assessment is a scientific technique which estimates the risk posed to humans or the natural environment by the exposure to a contaminant at a known concentration. Development of site specific criteria using risk assessment is called Site Specific Risk Assessment (SSRA). Actual site information, such as soil type, is substituted for the assumptions used in the generic criteria. As a result, site specific clean-up criteria are often numerically higher (less stringent) than the generic criteria, while still protective of human health and the environment.

The proposed guideline allows Site Specific Risk Assessment (SSRA) as an alternative to the use of MOEE generic or background clean-up criteria.

Risk Management techniques can also be incorporated after a SSRA is undertaken. Risk Management involves engineering technologies that cap, isolate, ventilate/monitor the contaminants and leave them on site rather than undertaking steps to reduce or remove contaminants. The use of on-site technologies to reduce risks raises three major issues: contaminants must be monitored, facilities maintained in perpetuity, and responsibility must be assumed for funding and maintaining these facilities.

When using SSRA and Risk Management technologies to develop site specific approaches instead of remediating to generic or background criteria, a number of conditions are proposed in the guideline. For example the SSRA should be peer reviewed and a broad based community consultation program should be carried out (refer to section 7.4 of the proposed guideline).

Scope of this Report

This report focusses on the costs of site clean-up using the proposed generic approach which represents a significant change in the clean-up guideline. It compares the costs under existing guidelines to costs under the proposed guidelines for the two most common land use categories, residential and industrial.

Analyses of clean-up criteria values based on background levels or developed through site-specific risk assessment have not been carried out in this report because these approaches remain available to property owners.

The use of SSRA may provide cost savings for some site clean-ups because actual site information, such as soil type, is substituted for the assumptions used in the generic criteria. As a result, site specific clean-up criteria are often numerically higher (less stringent) than the generic criteria, while still protective of human health and the environment.

III. ANALYTICAL PROCEDURES AND DATA SOURCES

Of the seven case studies completed, three were prepared by Regional Operations Division (ROD) staff and four by a consultant contracted by the Canadian Petroleum Products Institute

(CPPI). A brief description of the method used and assumptions applied to generate the estimates is contained in Appendix A.

The three case studies (one for each of Central, West Central and South Eastern Region) prepared by ROD staff, provide estimates of the effects of different land uses and generic clean-up approaches on the necessary clean-up activities for each site.

The sites are:

- Site 1 - a site created by filling lake frontage with material that contains inorganic contaminants of concern in relatively low concentrations;
- Site 2 - a site occupied by an operating gas station with petroleum derived chemicals of concern; and
- Site 3 - an industrial site with inorganic chemicals of concern and some petroleum contamination.

The four case studies completed by the Canadian Chemical Products Institute (CPPI) are based on data from one gasoline service station site in Toronto but assume different groundwater depth (shallow or deep) and soil type (sand or clay) to arrive at the following four representative sites:

- Site 4a - Shallow water table with sandy soil
- Site 4b - Shallow water table with clay soil
- Site 5a - Deep water table with sandy soil
- Site 5b - Deep water table with clay soil.

The contamination assumed to be present at each of the four CPPI sites is based on one actual site and is therefore identical at all four sites. Soil type and water table depth are not varied in the proposed generic clean-up criteria. These variables are presently used in the 1993 MOEE *Interim Guidelines for the Assessment and Management of Petroleum Contaminated Sites in Ontario* through use of a decision tree. Under the proposed guideline, site-specific risk assessments may be undertaken to explicitly account for these and other variables.

The analysts who prepared the estimates for the seven case studies made estimates of the volume of soil considered contaminated under scenarios to meet clean-up approaches allowed under the current guidelines and under the proposed guidelines. This permitted a comparison of the effects of changing the guidelines.

The CPPI duplicated the volume of soil estimation exercise undertaken by Ministry ROD staff, and applied estimated costs of clean-up to the volume of contaminated soil at a site to arrive at an estimated change in the cost of clean-up under the proposed guidelines. This report applies

the same cost assumptions used by the CPPI to develop clean-up cost estimates of soil volume provided by Regional Operations Division staff. A breakdown of the cost assumptions is contained in Appendix B.

Combining the two land use categories (as noted earlier, the agricultural scenario was omitted), with the two groundwater uses and the two depth approaches (2x2x2) for each of the seven case studies provided the Ministry with 56 data points to evaluate the generic approach under the proposed guideline. Results of the analyses are presented in Table 3 and Figures 1-8 and summarized in the next section.

IV. RESULTS

A residential clean-up scenario represents the circumstances under which a proponent chooses to clean-up to generic soil standards required for the site to be used for future residential/parkland uses. The proponent will have either potable or non-potable groundwater present at the site and can choose either a stratified or full depth clean-up approach.

As indicated in Figures 1-4, the scenarios allowed under the proposed guidelines for residential clean-up could impose no incremental cost increases under several circumstances as indicated by the CPPI sites, could cause cost increases of up to 118% as indicated by Site 3, and cost reductions of up to 67% for proponents as indicated by Site 1.

An industrial clean-up scenario represents the circumstances under which a proponent chooses to clean-up to generic soil standards required for the site to be used for future industrial/commercial uses. For some contaminants, these standards are less stringent than for the residential/parkland use category. Within the scenario, the proponent will have either potable or non-potable groundwater present at the site and can choose either a stratified or full depth clean-up approach.

As indicated in Figures 5-8, the scenarios allowed under the proposed guidelines for industrial clean-up could impose no incremental cost increases under several circumstances as indicated by site 4a, could cause cost increases of up to 123% as indicated by site 4b, and cost reductions of up to 50% for proponents as indicated at site 2.

CPPI Estimates

Based on the estimates prepared by CPPI, proponents with sites that contain petroleum based contamination and who clean them up to meet the proposed guidelines for residential use will likely incur no increase in costs compared to the current guidelines, regardless of the type of soil located on the property.

Soil concentration standards specified in the *1993 Interim Guidelines for the Assessment and Management of Petroleum Contaminated Sites in Ontario (Interim Guidelines)* have been adopted in the proposed guidelines resulting in no change in clean-up requirements for these types of sites and consequently no change in costs.

According to estimates, however, the introduction of the stratified approach offers a proponent the opportunity for cost savings of an estimated $150,000 average at the four sites (see Table 3, column R-N-S) or 23%-48% of costs under current guideline, when non potable groundwater is present.

Under the industrial clean-up scenarios the largest cost increases could occur at sites with clay type soils (Sites 4b and 5b, Figure 5). Under the *Interim Guidelines*, clean-up is allowed to less stringent standards than those listed in the proposed guidelines. The result is estimated cost increases of between 2% (under the stratified non-potable groundwater approach) to 123% (under the full depth potable groundwater approach).

However, cost savings could be realized at Sites 4a and 5a for industrial clean-up because current requirements under the *Interim Guidelines* are more stringent than those proposed for clean-ups for sites with sandy type soil. Cost savings range from a high of 48% at Site 5a to 31% at site 4a (in both cases under the stratified depth clean-up with non potable groundwater, Figure 8).

For sites with petroleum based contamination, a change in the clean-up costs using the proposed generic clean-up criteria will occur as a result of the decision tree currently contained in the *Interim Guidelines* not being adopted in the proposed guidelines. In a separate analysis, not presented in this report, cost changes ranging from cost increases of 23% (under the full depth potable groundwater scenario) to cost savings of 23% under the non-potable stratified scenario have been estimated by the CPPI in the residential land use category under the proposed guideline compared to the approach allowed under the *Interim Guidelines*. Proponents will have the option of considering site specific variables such as presence or absence of basements, variability in soil type, or proximity to sensitive surface water bodies all of which are currently part of the *Interim Guidelines* as part of a site specific risk assessment.

The Ministry also wanted to investigate the difference in cost associated with the choice between full depth and a stratified clean-up. Holding both land use and groundwater use constant, the stratified clean-up cost under the proposed guideline was compared to the cost of a full depth clean-up for the four CPPI case studies. The stratified approach was less costly than the full depth approach in 50% of the scenarios (those where non-potable groundwater is present) and equal in cost for the remaining 50%.

MOEE Estimates

Site 1 presents a situation where the proposed guideline will allow proponents to remediate a site at much lower costs than the extremely high costs (about $3.4 million) under the current guidelines. A maximum of 67% savings in cost could be realized under the residential, non potable, stratified scenario (Figure 4). It represents a site where, as a result of creating the proposed guidelines, the standards for the contaminant driving the clean-up effort (mercury) are **less stringent**. This is the case for 3 of 22 contaminants listed in the present guidelines (see Table 2). While it is not known how many sites are contaminated by mercury in the province, the exercise does indicate the effect of the proposed guideline when a site has one predominant contaminant with proposed less stringent clean-up level.

The estimates of the clean-up volumes at Site 2, a gasoline station, are comparable to estimates made by the CPPI and therefore tell a similar story. Small differences in cost of clean-up are estimated for residential scenarios from current guidelines (Figures 1-4), and cost savings are estimated in the industrial category as a result of sandy type soil (Figures 7 & 8). The difference from the CPPI results lies in the presence of lead contamination at the site.

Site 3 represents a site where, as a result of MOEE undertaking the establishment of new multi-media standards for a contaminant, the revised requirement translates to increased costs (as much as 123% in this case where the primary contaminant of concern is lead) for seven of the eight scenarios analyzed.

The proposed more stringent clean-up requirements for lead contained in the proposed guidelines are under public review separately through the Advisory Committee on Environmental Standards. (see Rationale Document for the Development of Soil, Drinking Water, and Air Quality Criteria for Lead, October, 1993). Accordingly, more stringent lead standards may be adopted independent of this guideline revision. As a result, the estimated higher costs exhibited at Site 3 would have been incurred under the present guidelines.

When the proposed more stringent lead standards are included in the base case, estimates of soil volumes considered contaminated indicate the effect of the more stringent standard on the cost of clean-up. Cost changes at Site 3 include savings of up to 39% for half of the eight scenarios and no change in costs for the other half.

Again, while it is not known how many sites are contaminated by lead in the province, the results for site 3 indicate the effect of the proposed guideline when a site has one predominant contaminant with more stringent revised clean-up level. Only a maximum of 3 of 22 contaminants listed in the present guidelines have become **more stringent** under the proposed guidelines (see Table 2).

In order to assess the choice between a stratified and full depth approach, the clean-up cost under the proposed guideline associated with the a stratified clean-up was compared to the cost of a full depth clean-up, holding both land use and groundwater use constant. For the three MOEE case studies, the stratified approach proved less costly than the full depth approach in 67% of the scenarios and equal in cost in the remaining 33%.

Table 3
COST DIFFERENCES FOR DECOMMISSIONING CASE STUDIES

	CLEAN-UP SCENARIO															
SITE	**R-P-F** *(Fig. 1)*		**R-P-S** *(Fig. 2)*		**R-N-F** *(Fig. 3)*		**R-N-S** *(Fig. 4)*		**I-P-F** *(Fig. 5)*		**I-P-S** *(Fig. 6)*		**I-N-F** *(Fig. 7)*		**I-N-S** *(Fig. 8)*	
	($000's)	**% ⌂**	**($000's)**	**% ⌂**	**($000's)**	**% ⌂**	**($000's)**	**% ⌂**	**($000's)**	**% ⌂**	**($000's)**	**% ⌂**	**($000's)**	**% ⌂**	**($000's)**	**% ⌂**
Site 1	-1,019	-30%	-1,986	-58%	-1,019	-30%	-2,306	-67%	-738	-39%	-754	-40%	-738	-39%	-754	-40%
Site 2	12	16%	12	16%	12	16%	12	16%	12	16%	12	16%	-22	-31%	-36	-50%
Site 3	373	118%	286	91%	373	118%	278	88%	39	62%	39	62%	7	11%	-1	-2%
Site 4a	0	0%	0	0%	0	0%	-151	-23%	0	0%	0	0%	0	0%	-137	-31%
Site 4b	0	0%	0	0%	0	0%	-151	-23%	362	123%	362	123%	142	48%	6	2%
Site 5a	0	0%	0	0%	0	0%	-99	-24%	0	0%	0	0%	-174	-40%	-207	-48%
Site 5b	0	0%	0	0%	0	0%	-207	-48%	215	123%	215	123%	39	18%	6	3%

⌂ = Change

LEGEND

LIST OF SITES

Site 1 = ROD Document, Case 1 - CR/GTA
Site 2 = ROD Document, Case 2 - SER
Site 3 = ROD Document, Case 3 - WCR, Case A
Site 4a = CPPI Document, Case 1A, Sandy Soils
Site 4b = CPPI Document, Case 1A, Clay Soils
Site 5a = CPPI Document, Case 1B, Sandy Soils
Site 5b = CPPI Document, Case 1B, Clay Soils

CLEAN-UP SCENARIO

R-P-F: Residential Potable Groundwater with Full Depth Clean-up
R-P-S: Residential Potable Groundwater with Stratified Depth Clean-up
R-N-F: Residential Non Potable Groundwater with Full Depth Clean-up
R-N-S: Residential Non Potable Groundwater with Stratified Depth Clean-up
I-P-F: Industrial/Commercial Potable Groundwater with Full Depth Clean-up
I-P-S: Industrial/Commercial Potable Groundwater with Stratified Depth Clean-up
I-N-F: Industrial/Commercial Non Potable Groundwater with Full Depth Clean-up
I-N-S: Industrial/Commercial Non Potable Groundwater with Stratified Depth Clean-up

V. SUMMARY AND CONCLUSIONS

This paper has assessed the financial implications of the proposed clean-up guidelines through the use of case studies. The cost of clean-up under the current guidelines was compared to the cost of clean-up under various conditions under the proposed guideline at seven sites.

The proposed guideline allows the property owner to choose one of three clean-up approaches:

- Background Approach
- Generic Approach
- Site Specific Approach

The costs of using the generic approach were assessed because data was available for the seven sites for this type of clean-up approach. No assessment has been done comparing the costs of the other two approaches.

Each site in the analyses was considered under eight possible scenarios representing combinations of two land use categories (Residential/Parkland or Industrial/Commercial), two levels of clean-up (full depth or stratified) and two possible groundwater uses (potable or non potable)

Table 4
DISTRIBUTION OF CASE STUDY RESULTS BY CLEAN-UP APPROACH

Clean-up Approach	# of scenarios in which costs increase	# of scenarios in which costs decrease	# of scenarios in which costs do not change	Total (7 sites x 8 scenarios)
Full Depth	11	6	11	28
Stratified	10	12	6	28
Total	21	18	17	

Table 4 above summarizes the results from the case studies. It is clear from the analyses that the proposed guidelines will not necessarily increase or decrease costs in all cases but that the cost of clean-up depends largely on the contaminants present at a site.

Based on the seven case studies, costs decrease in eighteen scenarios, and increase in twenty-one scenarios. The cost decreases are particularly notable in scenarios where protection of potable groundwater is not required, where mercury contamination is present (Site 1) and where stratified depth clean-up is chosen. On the other hand, cost increases occurred under scenarios where potable groundwater protection is required, clay type soil is present (Sites 4b and 5b) or where lead contamination is significant (Site 3).

Of the eighteen scenarios under which costs decrease, twelve occurred as a result of allowing a stratified approach rather than requiring a full depth clean-up. Furthermore, an analysis of the clean-up costs associated with the choice between a full depth and stratified clean-up, given the same land use and groundwater use, indicates that in the majority of cases, the costs faced by a proponent under a stratified clean-up are less than under the full depth clean-up.

The potential for lower costs as a result of this flexibility in the proposed guideline is a significant finding.

While these conclusions hold only in applying the generic criteria clean-up approach contained in the proposed guideline, cost savings for clean-ups of some sites may be possible under use of the site specific risk assessment (SSRA) approach which allows greater flexibility than the generic approach but data to assess this option was not available. The disadvantage of carrying out SSRA is that it can be an expensive undertaking relative to the value of the property or to the cleanup costs using generic criteria. SSRA can also be time consuming to research, develop, and review. Large contaminated sites are usually the most likely candidates for cost savings under the SSRA approach.

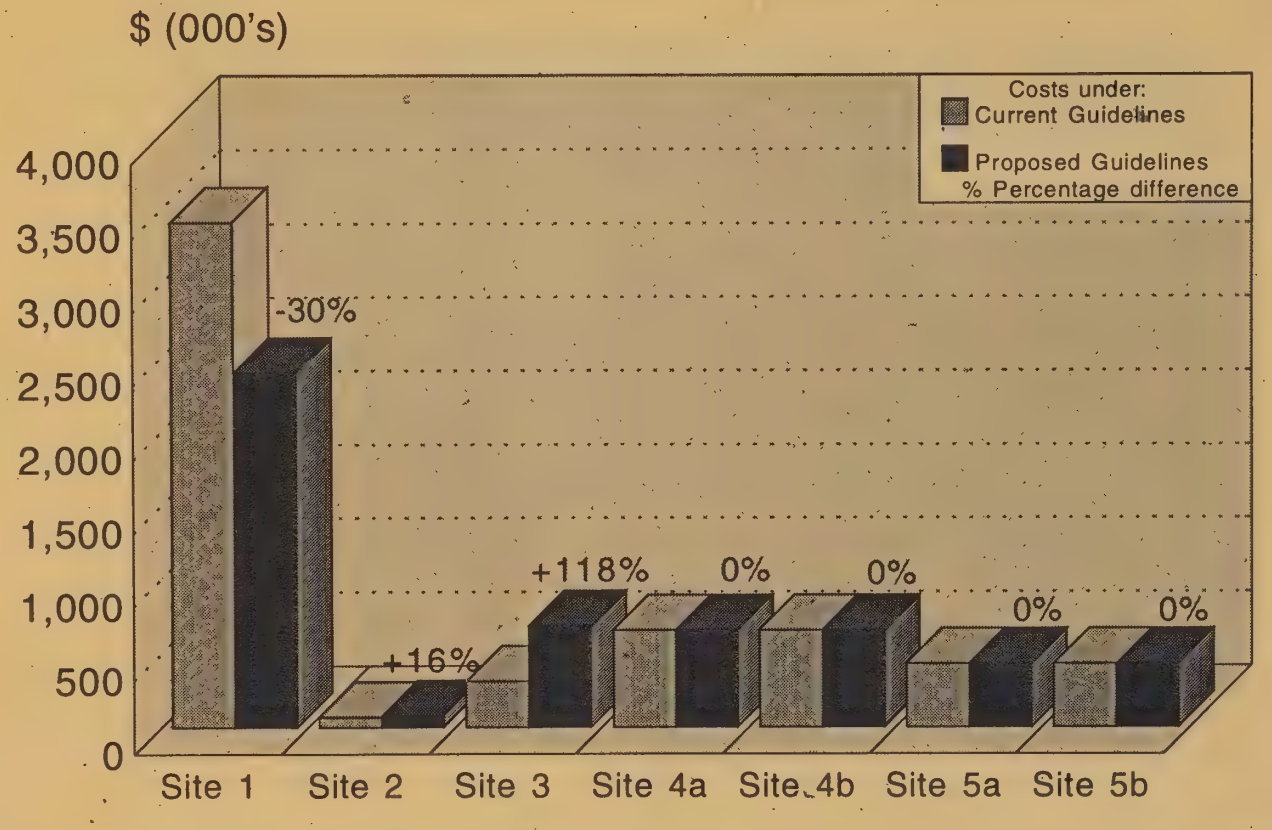
Furthermore, these analyses have focussed on the cost implications of the proposed guidelines for property owners. It is recognized that implications beyond this scope, such as public perception of reduced risk of health effects, or increased economic activity in the province may result from implementing the proposed clean-up guideline that have not been captured in these analyses.

LIST OF FIGURES

LIST OF SITES

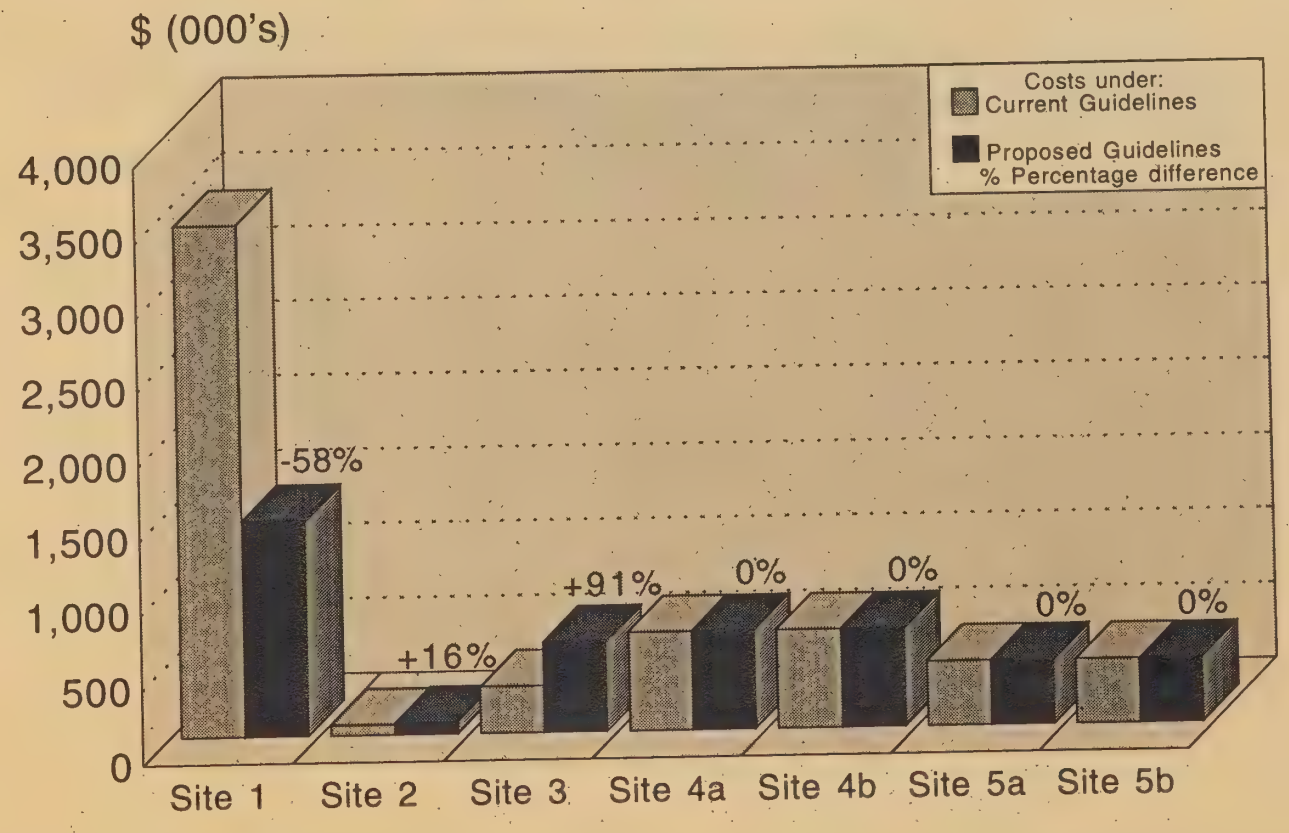
Site 1 = ROD Document, Case 1 - CR/GTA
Site 2 = ROD Document, Case 2 - SER
Site 3 = ROD Document, Case 3 - WCR, Case A
Site 4a = CPPI Document, Case 1A, Sandy Soils
Site 4b = CPPI Document, Case 1A, Clay Soils
Site 5a = CPPI Document, Case 1B, Sandy Soils
Site 5b = CPPI Document, Case 1B, Clay Soils

Cost Comparison of Current and Proposed Guidelines - Figure 1
Residential/Full Depth/Potable Groundwater



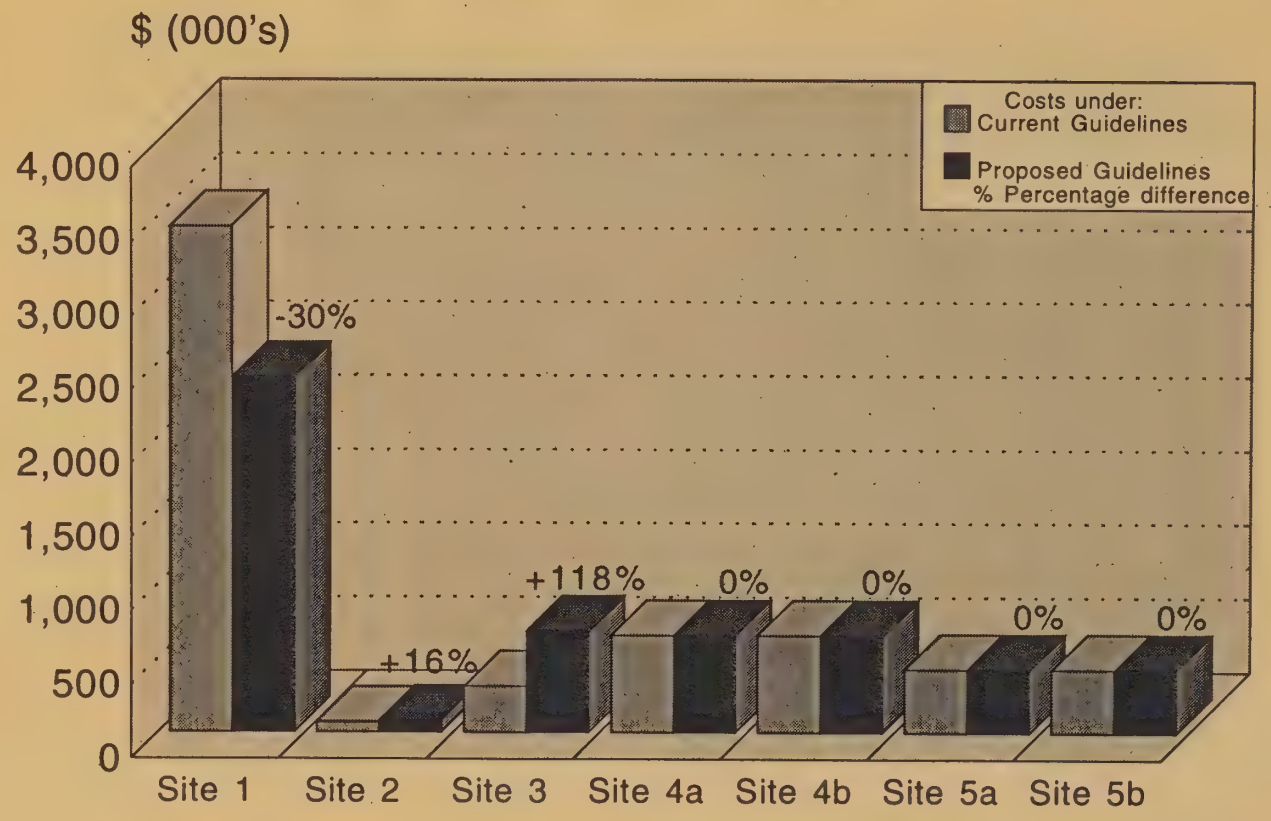
Residential-P-F=Full Depth Clean up with Potable Groundwater

Cost Comparison of Current and Proposed Guidelines - Figure 2
Residential/Stratified Depth/Potable Groundwater



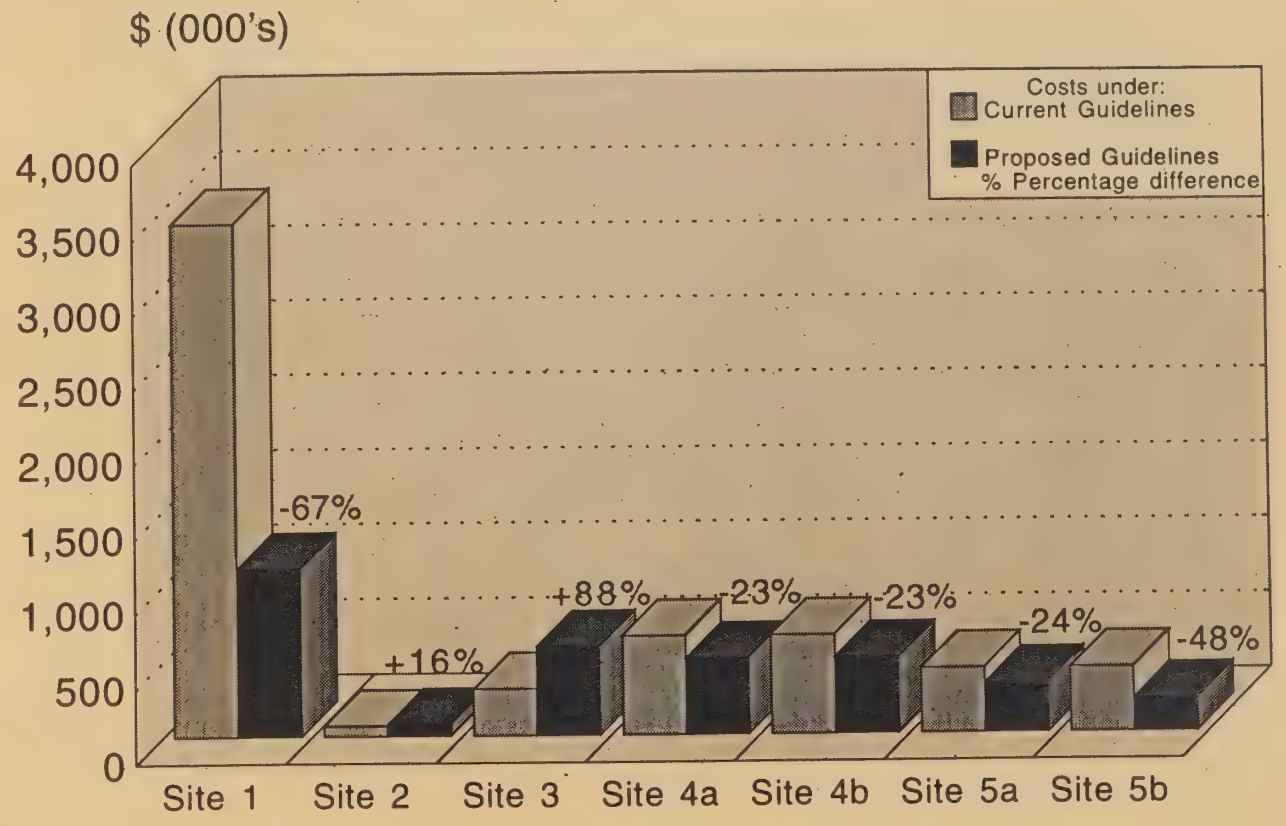
Residential-P-S=Stratified Depth Clean up with Potable Groundwater

Cost Comparison of Current and Proposed Guidelines - Figure 3
Residential/Full Depth/Non Potable Groundwater



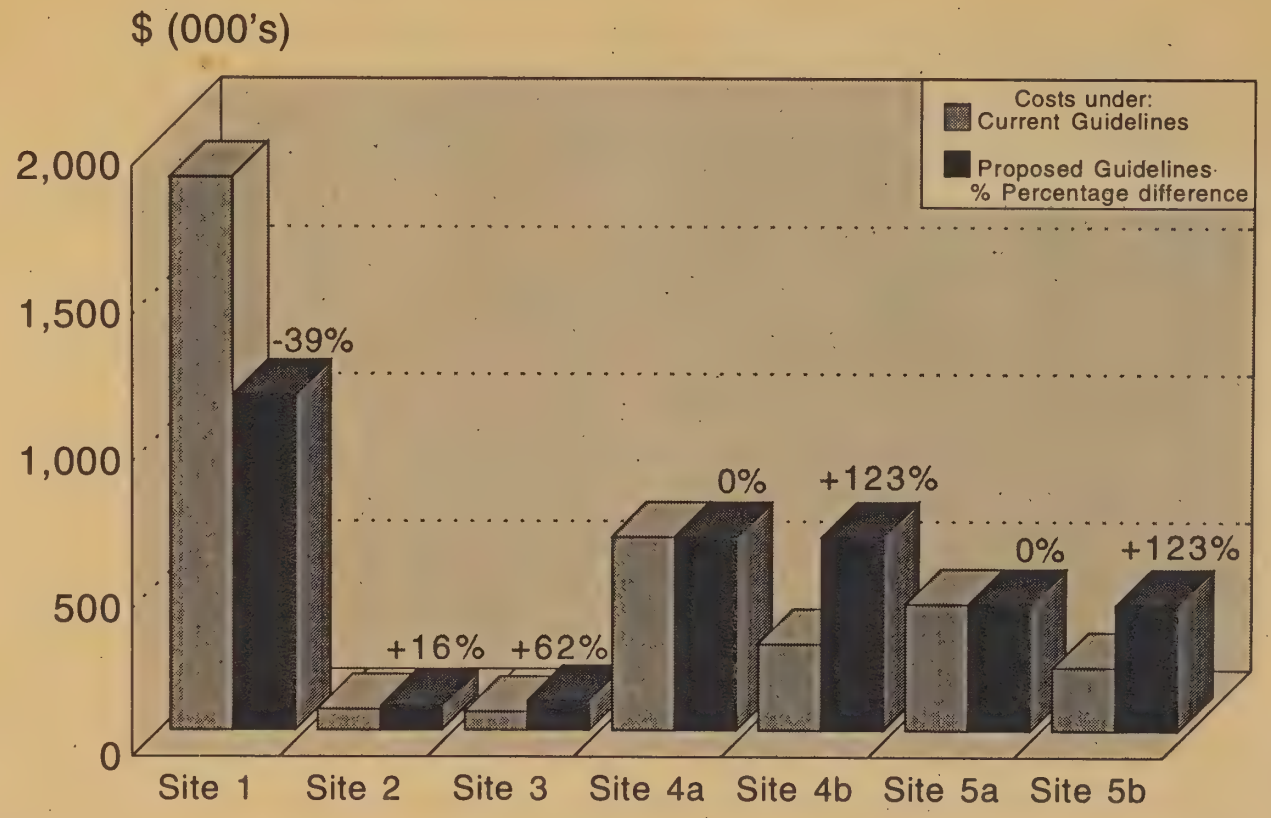
Residential-N-F=Full Depth Clean up with Non Potable Groundwater

Cost Comparison of Current and Proposed Guidelines - Figure 4
Residential/Stratified Depth/Non Potable Groundwater



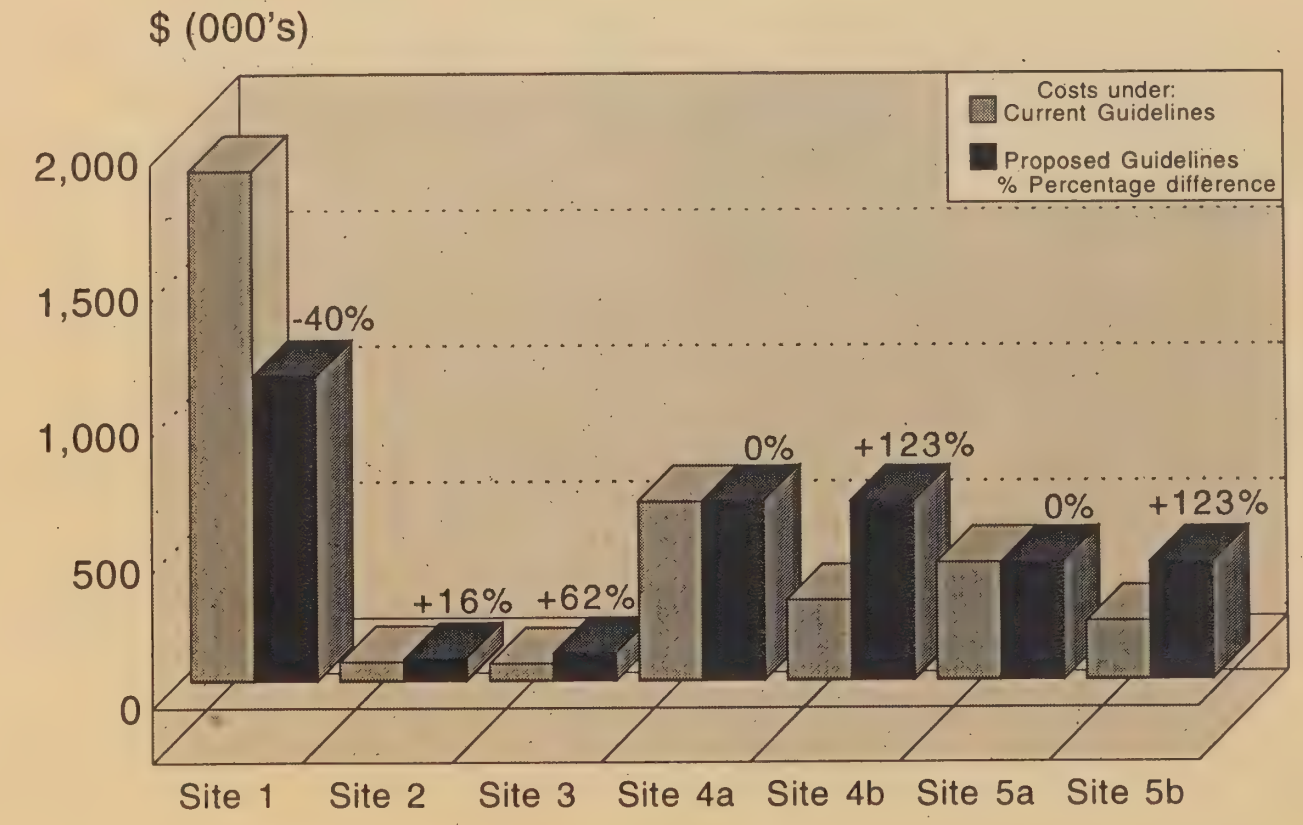
Residential-N-S=Stratified Depth Clean up with Non Potable Groundwater

Cost Comparison of Current and Propsed Guidelines - Figure 5
Industrial/Full Depth/Potable Groundwater



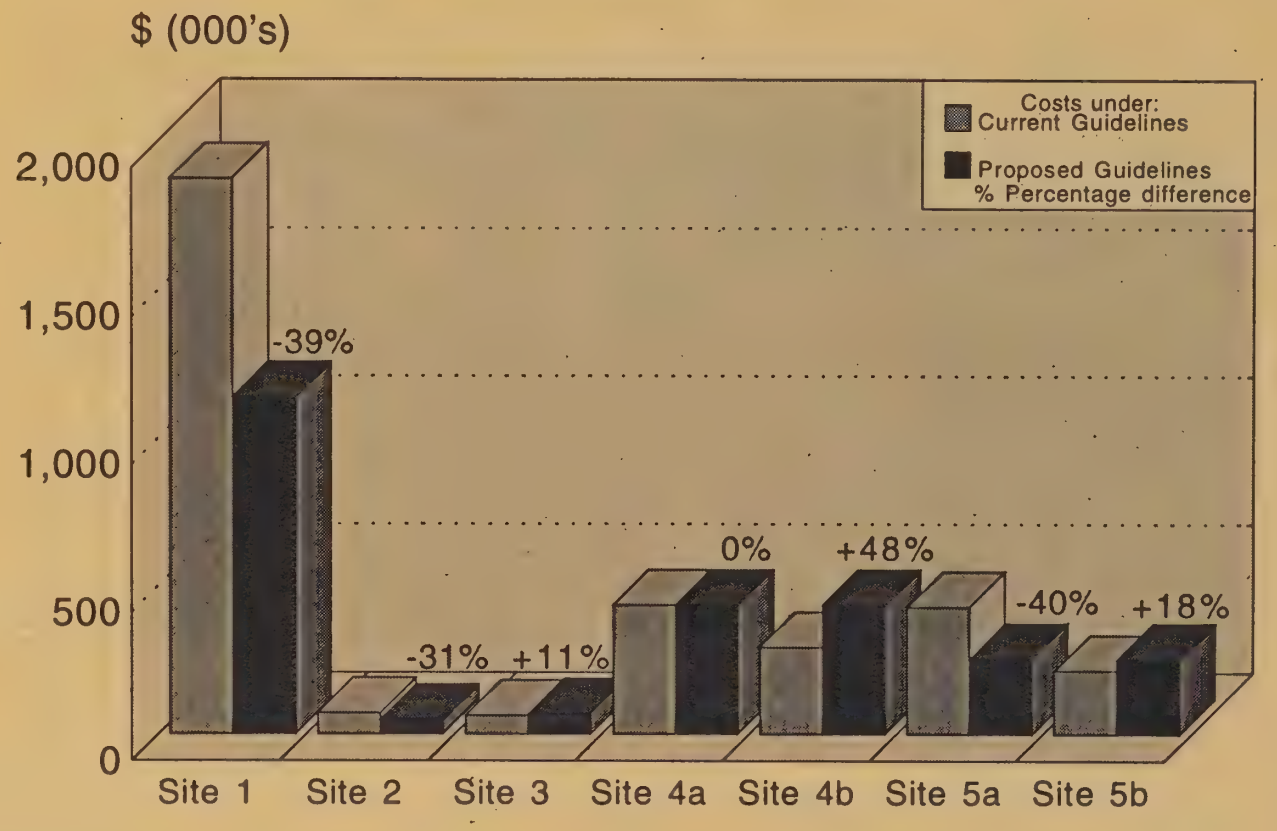
Industrial-P-F=Full Depth Clean up with Potable Groundwater

Cost Comparison of Current and Proposed Guidelines - Figure 6
Industrial/Stratified Depth/Potable Groundwater



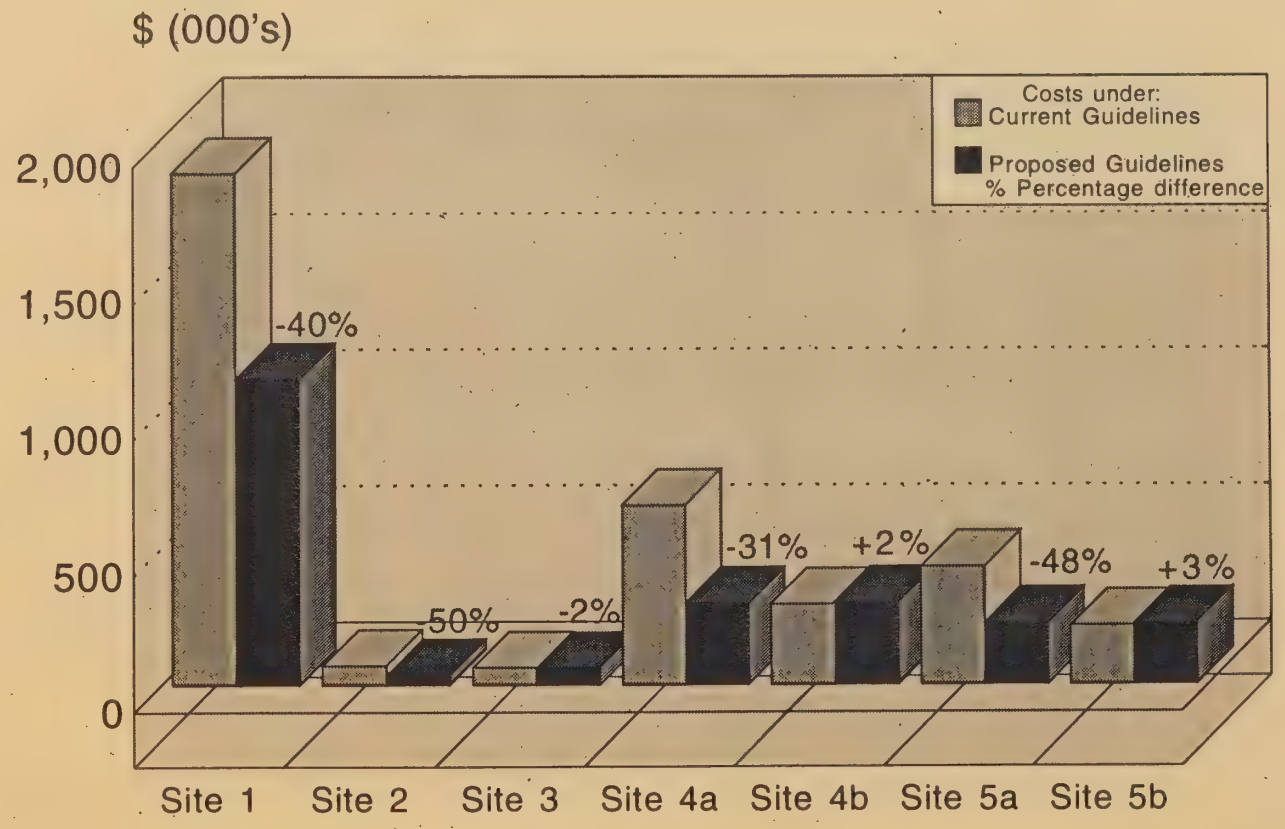
Industrial-P-S=Stratified Depth Clean up with Potable Groundwater

Cost Comparison of Current and Proposed Guidelines - Figure 7
Industrial/Full Depth/Non Potable Groundwater



Industrial-N-F=Full Depth Clean up with Non Potable Groundwater

Cost Comparison of Current to Proposed Guidelines - Figure 8
Industrial/Stratified Depth/Non Potable Groundwater



Industrial-N-S=Stratified Depth Clean up with Non Potable Groundwater

APPENDIX A

FINANCIAL IMPLICATIONS OF PROPOSED DECOMMISSIONING GUIDELINES USING CASE STUDIES

Methodology

Approach

Detailed site assessment information obtained from a random selection of contaminated sites (one from each of Central, West Central and South Easter Regions), were used to estimate the effects of a change in land use and clean-up targets under the proposed guidelines for each site. Changes in volume of *contaminated*[1] soil as the clean-up targets change were examined. In addition to the current decommissioning and clean-up guidelines, the following clean-up scenarios were considered.

Land use categories under the proposed guidelines:

- Residential\Parkland
- Industrial\Commercial

Within these broad approaches further consideration was be given to the following:

A. where the clean-up target is set to protect potable water;

B. where the clean-up target is independent of protection of potable water, but protective against other *effects*[2].

Two broad approaches within which the examination took place were:

1. where the clean-up will proceed to full depth ie. one clean-up target is used for the site

2. where the clean-up target will vary, above and below 1.5 m from surface ie. two clean-up targets are used for the site

The results of the examination answered the question "What is the volume of soil considered contaminated if the site has to be managed to meet approach ___ ? The approaches are defined in Table 1.

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[1]deemed to be soil containing chemicals above the applicable parameter targets

[2]effects such as vapour, odour and contaminant mobility concerns.

Table 1 - CASE STUDY APPROACH OUTLINE

Current Approach: the effect of the present guideline applied to depth of contamination for residential and industrial land use conditions

RES-P-F:	full depth remediation P\R land use potable ground water	IND-P-F:	full depth remediation Industrial/Commercial land use potable ground water
RES-N-F:	full depth remediation P\R land use no potable ground water	IND-N-F:	full depth remediation Industrial/Commercial land use no potable ground water
RES-P-S:	depth variable remediation P\R land use potable ground water	IND-P-S:	depth variable remediation Industrial/Commercial land use potable ground water
RES-N-S:	depth variable remediation P\R land use no potable ground water	IND-N-S:	depth variable remediation Industrial/Commercial land use no potable ground water

Table 2 summarises the relationships between the variables as outlined in Table 1, and the approach definitions. The current approach has not been placed in this table since it does not explicitly consider the noted variables. The current approach, however, served to establish a bench mark from which the relative effects of the various approaches may be considered (% difference).

Table 2 SUMMARY OF CLEAN-UP SCENARIOS

Level of Clean-up	Potable Ground Water Concern			No Potable Ground Water Concern		
	R\P Land Use	I\C Land Use	Agri Land Use	R\P Land Use	I\C Land Use	Agri Land Use
Use Surface Criteria to Full Depth	RES-P-F	IND-P-F	AGRI-P-F	RES-N-F	IND-N-F	N/A
Use Surface Criteria Above 1.5m and Use Stratified Criteria Below 1.5 m	RES-P-S	IND-P-S	N/A	RES-N-S	IND-N-S	N/A

R\P = Residential\Parkland Land Use category
I\C = Industrial\Commercial Land Use category
Agri = Agricultural Land Use category
N/A = Not Applicable

Simplifying Assumptions

For each site or case considered, the following assumptions were made:

- for the purpose of estimating volumes, the area of influence of a borehole is set at half the distance to the next borehole, in the direction of that borehole;
- these areas of influence will have rectilinear shapes and will be referred to as blocks;
- the zone of influence of a sample within a borehole (block) is equal to half the distance to the next sample (above and below the sample considered);
- the total volume of a site is limited by the depth of each borehole, ie. if boreholes extend to various depths, then the total volume within the area of influence of that borehole is limited by the depth of the borehole and should not be extended to the depth of the deepest borehole for the site;
- in determining whether or not a zone within a block is contaminated, comparisons may only be made for parameters already analyzed and reported, notwithstanding the availability of additional clean-up criteria targets.

APPENDIX B

COSTS APPLIED IN ASSESSING FINANCIAL IMPLICATIONS OF PROPOSED DECOMMISSIONING GUIDELINES USING CASE STUDIES

Typical current unit costs in the Toronto/Hamilton area used to calculate cost of clean-up

- Excavate and load contaminated soil . . . . . $ 2/t
- Haul and tip contaminated soil . . . . . $ 50/t
- Supply and place sand backfill . . . . . $ 9/t
- Project management, field supervision, environmental testing 10%
- Total (assume soil density 2t/m^3) . . . . . $ 134/m^3

Source: **Draft** Comparison of Site Clean-Up Scenarios Existing Interim Vs. Proposed New Guidelines, O'Connor Associates for Canadian Petroleum Products Institute, January, 1994.